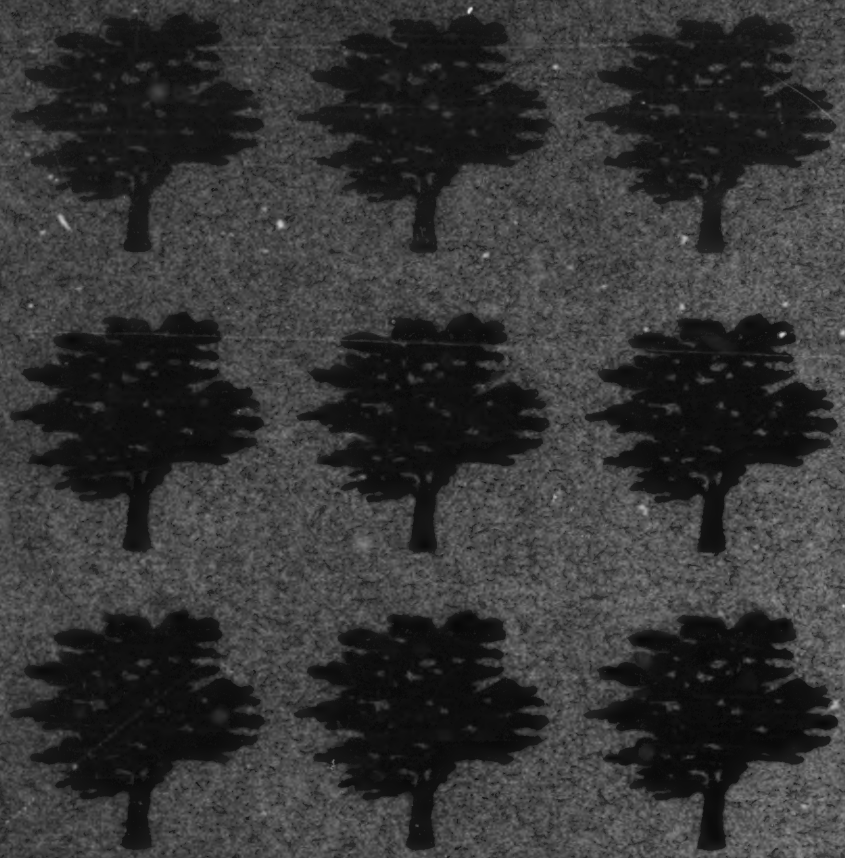


Sustainable Development and the Environment

United Nations Development Programme

Sustainable Development and the Environment

Environment and development, once thought separate issues, must now be considered jointly to ensure that human progress does not exhaust the resources of future generations. Safeguarding the global environment requires sustainable development. That is, development which guarantees a perpetuation of resources and skills that will meet tomorrow's needs.

Built into its programmes of technical assistance, the United Nations Development Programme (UNDP) is supporting countries in their endeavours to promote both human and sustainable development. UNDP is committed to the advancement of national and regional development programmes that preserve a healthy planet and ensure adequate resources for the future. Last year, nearly one-quarter of the 468 development projects approved by UNDP at headquarters were considered environmental in nature. More than US$500 million has been allocated for environmental activities under UNDP's ongoing projects.

Protecting the world's environment requires collective action. UNDP, the UN Environment Programme and the World Bank have joined forces to manage a Global Environmental Facility (GEF). The three organizations will use the GEF to channel technical, scientific and financial resources to middle- and lower-income countries for sustainable development. The GEF will promote and adopt environmentally sound technologies and help countries develop prudent environmental management. It will address such urgent environmental concerns as energy conservation, preservation of rich ecological diversity, combatting pollution of international waters, reduction of climate-changing greenhouse gases and protection of the ozone layer.

Through UNDP support, nearly 80 countries have participated in workshops on the environment and sustainable development since July 1988. In early 1990, UNDP launched the Sustainable Development Network which will ensure that information on environmental issues needed by policy makers and planners will be available throughout the developing world. UNDP's 112 field offices, serving more than 150 countries, will help link all governmental, non-governmental, grassroots and entrepreneurial organizations which can benefit from or contribute to environmentally sound development. In addition, environmental management guidelines are being put to use in UNDP field offices. These guidelines are aimed at bringing environmental considerations into governments' economic policy and project design.

To ensure that a realistic plan of action will be reached at the UN Conference on Environment and Development (UNCED) to be held in Brazil in 1992, UNDP is assisting developing country governments to prepare national reports and position papers.

UNDP's Regional Bureau for Latin America and the Caribbean, together with the Inter-American Development Bank, supported preparation for *Our Own Agenda*. This report discusses environmental issues pertinent to the region and will be presented at UNCED. Also in preparation for the conference, UNDP's Regional Bureau for Asia and the Pacific, with the Economic and Social Commission for Asia and the Pacific and the Asian Development Bank, sponsored a ministerial regional conference on environment and development, held in Bangkok, Thailand in October 1990. In addition, UNDP will support promotional activities to ensure that NGOs participate in UNCED.

In November 1990, UNDP pledged $5 million to help set up the Centre for Environment and Development for the Arab Region and Europe (CEDARE). This Centre will stimulate and co-ordinate environmental research in the region. CEDARE will initially focus on desertification and land degradation, pollution, urbanization and the preservation of freshwater resources and marine life.

The Africa 2000 Network was launched by UNDP to support NGOs and local organizations which are working to preserve the environment and promote ecologically sustainable development. Under the African regional programme, grants of up to $50,000 are offered to individual community groups.

UNDP is also contributing to the preparation of *World Resources 1992-93*, a report focusing on environment and development. This report will serve as an official conference document.

In the meantime, UNDP will continue its substantial involvement in a wide range of environmental concerns. As the following articles illustrate, the span of UNDP environmental activities extends from improving environmental health conditions to promoting alternative energy, conserving soils, reclaiming rangelands and protecting forests, watersheds and wildlife. ■

READEX FICHE

Turning a new leaf

Brazil Seeks Ecological Balance in the Amazon

By David Kinley

Azoury/SIPA

Vast expanses of tropical forest have been stripped for pasture.

Two hours east on the smoothly-paved BR-364 highway from Porto Velho stands the ramshackle home of Reinaldo de Sousa. Mr. De Sousa arrived in Brazil's frontier state of Rondonia two years ago after selling a small plot of tired land in Mato Grasso do Sul, 1,600 kilometres to the south. With a little cash, he secured a mortgage on a 50-hectare parcel awarded under the country's land reform programme.

With machete and fire, sweat and sacrifice, Mr. De Sousa has cleared four hectares where he grows maize, rice, manioc, sugar and a variety of tree crops. What he and his family don't eat, he peddles to passers-by on the highway. If the farming goes well and he makes his payments, Mr. De Sousa will own a sliver of the Amazon in six years.

No one said it would be easy. The rainy season has just arrived, and Mr. De Sousa's boots are caked with orange-red mud. His wife draws murky water from a hand-dug well. Their three small children face recurring bouts of malaria. Even the family puppy is scrawny. But Mr. De Sousa says he is here to stay. A hand-painted sign

BRAZIL

names this farm *Pouso Feliz* — Place of Happiness.

The question remains: does Mr. De Sousa represent Manifest Destiny or ecological catastrophe?

It is a question troubling many Brazilians as well as environmentalists overseas who fear that rapid deforestation of the Amazon could foreshadow a dangerous shift in global weather patterns. Mr. De Sousa, and the half-million settlers like him who have flooded Brazil's tropical Northwest, may see themselves as principled and hard working pioneers. But to others, they are villains — or, at best, pawns — in a drama full of avarice, indifference and intrigue.

Gonzalo de las Salas, a UNDP expert working to halt deforestation.

UNDP photo by David Kinley

The jungle appears to be bleeding

Settlement of the Northwest over the last two decades has provided painful lessons about the vulnerability of the Amazon ecosystem. An aerial view of Rondonia from 10,000 feet reveals a tropical canopy levelled in many areas by ranchers, farmers, and logging, mining and hydro-power operators. Once exposed, the thin and fragile tropical soils are alternately baked hard by the sun and eroded by heavy rains. The wide meandering rivers that feed into the Amazon turn from green to red with topsoil. From the air, the jungle appears to be bleeding.

But an on-scene look at current developments in Rondonia reveals that important steps are being taken to arrest the damage being done to the Amazon, and to be sure it doesn't happen again. It will take time, political will and further aid from abroad. One thing is certain: development of the region will continue to be a fundamental objective of Brazil, whose 145 million people remained, until recently, concentrated on the Atlantic coast.

The opening-up of the Amazon is rooted in a major policy decision that goes back to the early 1960s. Just as steam-powered railroads moved North American settlers westward in the mid-19th Century, the Brazilian government, with ample aid from international development banks, began building "penetration highways" to move men and machines into the western and northern frontiers. The coastal poor were coaxed by government advertising and promises of good cheap land. New tax laws encouraged jungle clearing for cattle ranching.

Burned tracts that resemble moonscapes

Like America's "wild west" of 150 years ago, settlement of the Amazon has been marred by land grabbing, displacement of indigenous peoples, and rapid, often reckless commercialization of natural resources. The consequences are all too clear from the window of a car or truck traversing the 1,400 kilometre BR-364 highway. Here, in the middle of the Amazon basin, the jungle has been stripped back nearly to the horizon. Countless trucks laden-ed with mammoth logs barrel toward

Settler Paulo Bomfim *(right)* grinds sugar cane into a tasty drink.

UNDP photos by David Kinley

Porto Velho's sawmills. Wide roadside stretches have been reduced to stump-studded grasslands sprinkled with shrubs and cattle. Interspersed between the grasslands are newly burned tracts that resemble blackened moonscapes.

Stripping of the forests reached a fever-pitch in the mid-1980s, just as Brazil returned to civilian government after twenty years of military rule. In 1980, only three per cent of Rondonia, a state three-quarters the size of France, was deforested. Eight years later, it stood at 17 per cent. Since the paving of BR-364, the deforested area has tripled. Last year, satellite photos documented 170,000 fires in the region as farmers and ranchers slashed and burned to clear more land.

Environmentalists and human rights activists charged the Brazilian government and international development banks with gross neglect in their development schemes. The burning of the forest — and the massive release of carbon dioxide into the atmosphere — has been directly linked to the gradual warming of the earth, the so-called "greenhouse effect." Some environmental experts accuse Brazil of committing "ecotastrophy," upsetting the climatic balance of the entire planet. "A calamitous cycle of destruction is unfolding in Rondonia," said an editorial last summer in the *New York Times*. "The tragedy is a lesson to Brazil and the international agencies that finance its projects."

A massive wave of migration

After heated public debate, there is now ample evidence that policymakers in Brazil, with help from the United Nations Development Programme (UNDP) and the international aid community, are taking these lessons to heart.

The main controversy over the destruction in Rondonia has centred on the US$1.5 billion "Northwest Brazil Integrated Development Programme," best known by its Portuguese acronym, "*Polonoroeste*." The programme was launched in 1981 with over US$440 million in loans from the World Bank. Reflecting government policy, the project sought to integrate the vast upper Amazon into the national economy by paving highway BR-364 from Cuiaba in Mato Grasso to Porto Velho, capital of Rondonia.

Polonoroeste was also designed to impose order upon a turbulent and often environmentally destructive wave of both government-sponsored and spontaneous migration into the region which had begun in the early 1970s. Operating through a regional development authority and the state government in Rondonia, the project was to provide financial and technical support for small farmers, improved health and education services to new planned settlements, and protection for vast tracts of virgin jungle and its Indian inhabitants.

From the beginning, however, the *Polonoroeste* programme was overwhelmed by forces beyond its control. "Alongside the modernization of the BR-364 highway," explains Marco Julio Chaves, an Interior Ministry official with long experience in the programme, "came a massive wave of migration from the south of Brazil, driven by dramatic changes in land tenure and a decline in agricultural employment. *Polonoroeste's* planned settlements in Rondonia," says Mr. Chaves, "became quickly surrounded by spontaneous squatters."

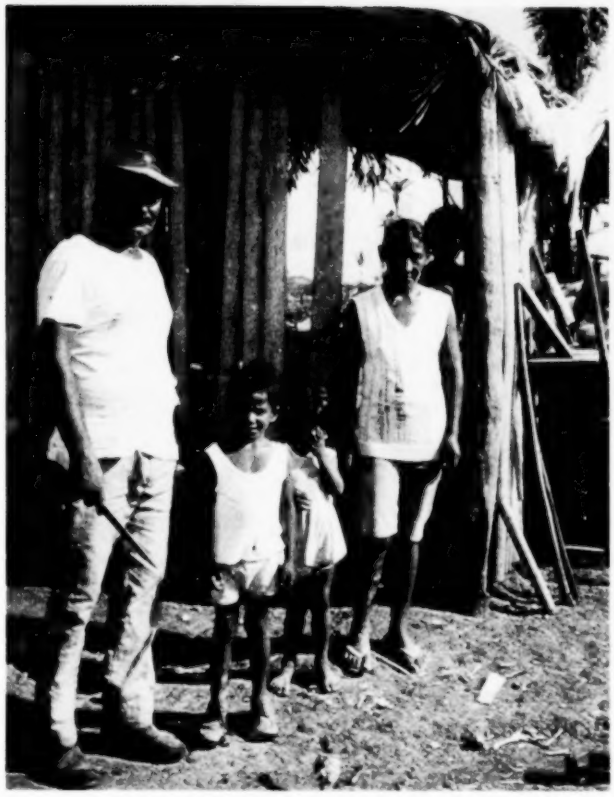
Ecotastrophy followed

World Bank evaluations reveal that the programme's laudable objectives were far too ambitious to be carried out with the limited funding allotted to it. Bank analysts conclude that *Polonoroeste* erroneously attempted to impose institutional complexity upon a frontier state government with limited managerial capacities. The activities of over 40 government agencies were supposed to be co-ordinated under the project, but given the shortage of skilled administrators, little co-ordination took place.

Soon after *Polonoroeste* was launched, economic recession and budget shortfalls hit the federal government, and Rondonia faced severe delays and outright gaps in Brazilian counterpart funds to support local project activities. Two years into the programme, subsidized credit to promote ecologically-sustainable small farm development was suspended.

The failure of *Polonoroeste* was also a matter of skewed priorities. Although hundreds of millions of project dollars enabled construction of the BR-364 road to be completed on time, most of the construction projects critical to orderly settlement and productive farm practices remained simply plans on paper. Ecotastrophy followed.

Confronting mounting criticism and threatened cuts in foreign aid, Brazil requested special assistance from UNDP aimed at halting the rapid destruction of the Amazon environment.



Farmer Reinaldo de Sousa and his family.

Agro-ecology: road to salvation?

In late 1987, a team supported by UNDP and the Food and Agriculture Organization (FAO) began working to develop a state-wide zoning system that defines land and resource use according to specific "agro-ecological" criteria.

A new map of the area — mandated by state law and implemented with the help of a US$120 million World Bank loan — designates areas suitable for cultivation and limited resource extraction. It also sets aside lands where no commercial exploitation will be allowed.

"Through imposition of agro-ecological zoning," says Mr. Wilson Tiburcio Nocoveiro, Rondonia's secretary of state for planning, "the State aims to preserve fully 70 per cent of its area in tropical forest." In line with the zoning system, incentives offered by the government — such as tax breaks which encourage ecologically destructive cattle ranching — are being eliminated.

The new zoning system has been welcomed by many longtime critics of *Polonoroeste*. "In the past, deforestation was the proof one needed for getting title over the land in Rondonia," says Steven Schwartzman of the Washington-based Environmental Defense Fund. "Agro-ecological zoning says that you won't get title unless you respect specific ecological criteria."

The UNDP-FAO team is also training over 300 Brazilian extension workers to help the current half-million settlers in adopting ecologically-viable farm practices. Annual crops such as corn and rice, which require tilling of the soil, are being discouraged in favour of tree crops like coffee and rubber that help to preserve soil fertility and reduce erosion. Critical to achieving these changes is increasing the effectiveness of state agricultural extension services and improvements in transporting and marketing new cash crops.

"We're getting the word out"

Under new regulations devised with UNDP and FAO assistance, burning of the forest will be outlawed, except by special permit. "We now have 26 local enforcement offices to curtail burning," says Haroldo Franklin de Carvalho, president of Rondonia's Forestry Institute. "We're getting the word out to farmers on the back roads that they have to change their practices or they'll be heavily fined."

It will not be easy to impose the new land-use zoning across an area as vast and wild as Rondonia. Indiscriminate logging and land clearing, and illegal invasions of Indian reserves continue in some areas. The recent assassination of Chico Mendes, a noted Brazilian environmentalist and forceful advocate for small-scale rubber-tappers in the Amazon, demonstrates the persistence of lawlessness in the region.

The seriousness of the past destruction and the challenge to contain it, however, has mobilized officials at the highest levels of the government in Brazil and the international aid community abroad. Brazil's new constitution, enacted in October 1988, contains provisions for protection of the environment which are among the most stringent in the world. President José Sarney recently announced a series of federal measures to cut off government aid to "predatory" development projects that further threaten the Amazon environment. Moreover, since taking office his administration has created nine new national parks and set aside more lands for Indians than any previous government.

The UNDP-FAO team is working with the government and the World Bank in the formulation of a new multi-

Aristel de Oliveira grows tree crops like guarana, used in a popular Brazilian drink.

UNDP photo by David Kinley

billion dollar *Polonoroeste II* programme. Aimed at fulfilling many of the unrealized promises of the programme's first phase, the new project will emphasize alternative strategies for agricultural development suited to specific ecological zones. It also aims to provide much needed social services such as improved health care. Malaria remains rampant in the region.

"New roads have to be stopped"

Conservationists such as Barbara Bramble of the World Wildlife Federation are cautiously supportive of these initiatives. "Present settlement areas must be economically consolidated," she says. "But new roads have to be stopped."

Visits to settlers near the BR-364 highway show that consolidation is already underway. Aristel de Oliveira's coffee and rubber farm in a remote settlement known as Alto Paraiso — 20 kilometres into the forest from the main highway — is one example of how government help can turn jungle destruction into a profitable and sustainable enterprise. Mr. De Oliveira has owned his 78-hectare parcel for only three years, yet he has planted 35,000 seedlings over a 25-hectare spread. The seedlings and technical guidance were provided by EMBRATER, the national farm extension service. Backed by US$4.6 million in funding from UNDP, EMBRATER is redirecting its efforts away from aiding large-scale farming and is now concentrating on helping owners of small tracts.

Mr. De Oliveira is president of a 30-member coffee growers association recently formed in Alto Paraiso with help from EMBRATER. The growers share processing equipment and technical information, and plan to rent a truck to market their coffee. Last year, Mr. De Oliveira sold 160 forty-kilo bags of coffee for US$600 — enough money to install a new water tank next to his house.

In the Alto Paraiso community centre built with *Polonoroeste* funds, other farmers' groups meet to discuss their recent progress. "I didn't have work or land back in Paraná," says Olimpio Sanagioto. "Now I am growing coffee, and sharing a generator, water pump and coffee-cleaning machine with my neighbours."

"Technical assistance from EMBRATER has been instrumental in the formation of eight successful small farmers' groups in this settlement," says Samuel Gomes Neves, a farm extension worker with the *Polonoroeste* programme. "These farmers can make a decent living and preserve the land if only they are given a little government help."

Just a few kilometres from Reinaldo de Sousa's home on the BR-364 highway is the more prosperous farm belonging to Paolo Bomfim. He came with his brother from Rio de Janeiro four years ago after spending many years working at sea. With help from EMBRATER, the Bomfims are making a good living cultivating 16 hectares of coffee, bananas, cashews, coconuts and a variety of staples in a mixed cropping pattern. They plan to plant more trees, purchase milk cows and expand their flock of chickens and ducks.

"Here I am free"

Pulling down a dusty shotgun from the wall of his bedroom, Mr. Bomfim explains that "there was warfare all around here a few years ago. Bandits were shooting people and stealing the land. Now things are calmer and we're getting good help from the extension service." Offering some freshly-crushed sugar cane juice, he adds: "You can keep Rio de Janeiro. Rondonia is my paradise. Here I am free."

Few who have challenged the dense vegetative bounty of Amazonia have found their paradise — or as the Brazilians say, their "*el dorado*." Faced with violence, malaria and daunting economic circumstances, even fewer have found freedom from want. But Brazil's most destructive and humiliating development experience is now on record for the world to see. And with the help of UNDP and other aid donors, the government aims to transform the region into an ecologically-sensible model for the rest of the Amazon to follow. So far, the new look in the development of Rondonia shows every sign of overcoming the errors of the past. ■

Sid Kane/UNDP

Burning coal for energy pollutes the air of many Chinese cities, such as Shanghai, where a barge laden with coal plies the Huangpu River.

China's New Environmental Ethic

While short of funds, Beijing is beginning to move against pollution

By Sid Kane

Shanghai, China—Every year, China produces 700 million tonnes of industrial waste, much of it ending up in lakes and rivers that have taken on a metallic, rust-brown colour. The polluted tributaries that branch off the Yangtze, like the clouds of black smoke spewing from China's innumerable factories here, are the unwanted dividends of an era of unchecked industrialization.

"I can remember when the air near Shanghai was clear, the fields green and the rivers jumping with fish," says one government official. "In just two decades it has all changed. Today many rivers are dead, and you can feel the dust from pollution on the flowers and trees."

Pressed to modernize its economy while meeting foreign debt obligations

and better providing for a growing population of 1.1 billion, China has sought to increase industrial productivity and foreign exchange above all else. But acid rain has crippled important forests and crop areas, while widespread air and water pollution have diminished the splendour of many of China's age-old, imperial cities. All of which has spurred the government to rethink its development goals and search for ways to at least prevent making a bad environmental situation worse.

Strapped for cash, China cannot afford expensive technologies to protect its air and water resources. Nor is it feasible to curb coal consumption—the main cause of air pollution—while the country's population is growing by 17 million a year. But increasingly, Chinese officials are openly voicing concern about the environment, and have made the issue a national priority for the coming decade. "We want solutions," says Zhang Chonghua, Director for Research and Development at China's National Environmental Protection Agency (NEPA). "But like other developing countries, we cannot pay for expensive prevention programmes."

Even so, Mr. Zhang, a young energetic scientist who spent his college years in the US, says that a new environmental ethic has begun sweeping the country. "The government is willing to take actions and share global responsibilities with other nations," he says.

A case in point is China's decision to sign an international accord last June that commits nations from across the globe to join in safeguarding the earth's ozone layer. The agreement will help speed the phasing out of harmful chloroflurocarbons (CFCs)—one of the three main greenhouse gases. CFCs are responsible for depleting the ozone layer.

"We have already given the order to stop creating new factories that produce CFCs," Mr. Zhang says, "and are studying alternatives with help from the United Nations Development Programme (UNDP)." In a recent study by the World Resources Institute in Washington, which ranked countries by their annual emissions of greenhouse gases, China placed fourth, following the United States, the Soviet Union and Brazil.

UNDP has funded a feasibility study for China that has identified several substitutes for CFCs. These will be tested over the next three years. CFCs are used extensively in the manufacture of fire extinguishers and refrigerants, which are produced on crowded assembly lines in Shanghai, the country's main port and industrial centre. The plan proposes steps to cut emissions by 40 per cent by 1994 at a cost of US$41 million.

"We hope to use the study to gain control over the CFC problem," says Bai Changbo, a programme officer at NEPA. "It is important for the economy as well," he adds. "China must stop using CFCs if it wants to export to markets that are adopting legal restrictions against their use."

Xie Guangming, an engineer at the Beijing Solar Energy Research Institute.

Damage to the earth's ozone layer is not the only environmental problem troubling the Chinese. Air pollution, largely prompted by the burning of soft coal for energy, has showered acid rain on provinces in the south and increased health risks in many cities. "We have epidemiological data showing that bronchial and respiratory illnesses are much more serious and widespread in urban industrial areas, where coal-burning is abundant," Mr. Zhang says. On the worst winter days in Beijing, when coal burning is rampant, soot-filled "black winds" have been known to darken the city's streets, reducing visibility and obscuring distant sights from view.

According to government figures on air quality in Beijing during 1985, the concentration of air-borne dust from coal-burning was 14 times higher than in Tokyo and 13 times higher than in New York. Over 15 million tonnes of sulphur dioxide was discharged into the country's air that year, exceeding national safety limits in many cities. Coal dust, suspected of causing cancer, also contributes to acid rain formation, which has devastated forests and crops in China's Guangdong Province. In this province alone, acid rain is blamed for losses of more than $400 million a year.

Laboratory director Shi Lu Huai with a device used to measure wind currents.

Photos by Sid Kane/UNDP

A Shanghai refinery extracts a variety of precious metals from industrial wastes.

Preventing only one tonne of sulphur dioxide from reaching the air by installing advanced anti-pollution technology would cost China $1,000, says Ma Guo Jun, an engineer for the Environmental Protection Research Institute of Electric Power in Nanjing, which is known for its wide, tree-lined avenues and ancient monuments. Mr. Ma, who is also director of a UNDP and World Health Organization project that is helping China find safe sites for power plants, says it is a cost that the country cannot bear.

"We're not yet able to eliminate all the hazardous air pollutants, so we're finding the best ways to disperse them in the atmosphere," he says, referring to the project that he directs. Its goal is to help scientists analyze wind flows at potential sites for new coal-burning power stations, and to determine the dangers posed to nearby communities. In the past, Mr. Ma says, a number of power plants were constructed in the worst possible places.

As part of the project, UNDP has provided study tours abroad along with equipment to measure pollution levels and wind conditions. In a brightly-lit laboratory in a field behind the Institute's main buildings, scientists use a newly-built wind tunnel to simulate wind speeds and their effects on smokestack plumes. On this day however, a power outage—now a routine occurrence here—has rendered the futuristic assemblage useless. "We've gotten used to this happening," laments one frustrated scientist.

To make its air safer to breathe, China is also encouraging the use of a cleaner-burning coal for homes and factories. In addition, it is speeding the development of renewable geothermal, solar and hydropower energy sources, especially for remote areas like Tibet, where UNDP is currently investing $5.1 million in rural electrification.

Perhaps the greatest damage to China's environment is being wrought by industrial waste, large amounts of which are toxic and are routinely discharged into lakes and rivers. Of the 700 million tonnes of industrial waste produced in China each year, 26 per cent is now recycled. This includes 15 million tonnes of fly ash, which is used in building materials for roads and homes.

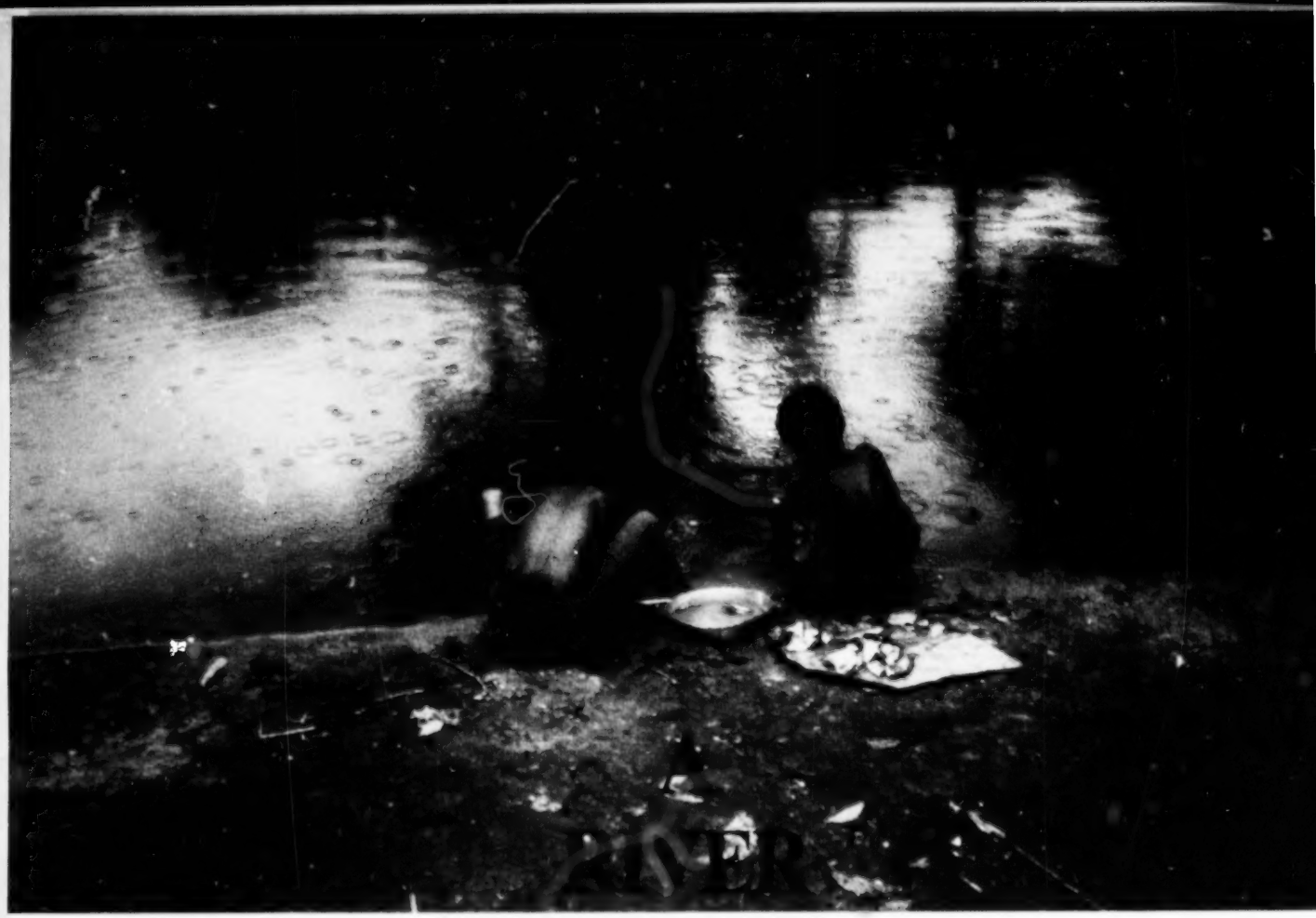
Now a new effort supported by UNDP and the United Nations Industrial Development Organization will enable China to recycle large quantities of precious metals—such as platinum, gold and silver—from left-over scrap and industrial sludge. "The country lacks these resources, especially platinum, which is why extracting them from industrial wastes is so important," says Shou Hongxiang, Director of the Shanghai Precious Metals Refinery. Outside the plant's old factory buildings, large mounds of twisted scrap metal, including engine parts and catalytic converters, stretch in all directions. Strong chemical odours seep from the plant's recycling laboratories.

Last year, workers at the precious metals refinery processed 20,000 tonnes of waste materials and retrieved 280 kilogrammes of platinum and 350 kilogrammes of gold. As a result of study tours that took scientists to modern refineries in the United Kingdom and the US, and with new equipment on order, Mr. Shou expects recovery yields to rise by 40 per cent.

While helping to protect the environment, the programme could also lower the nation's balance-of-payments deficits. China pays over $60 million to import six tonnes of platinum each year, which is used by the automotive, petro-chemical, medical and telecommunications industries. Through recycling, the government expects to considerably lower this bill.

"Finding innovative solutions for industrial wastes, like taking steps to eliminate CFCs and improve our air quality, is all part of a new era in China," says NEPA's Mr. Zhang. "We want very much to find technologies to protect our environment, and to join with other countries in safeguarding the ecology of the world." ■

Shou Hongxiang, director of the Shanghai Precious Metals Refinery.



PAPUA NEW GUINEA

CHANGES COURSE

Setting a net for catching scarce fish samples in the Sepik River.

By Cherie Hart

It was a simple purchase in a local aquarium shop — a plant to keep the tropical fish company. But like the scenario of a science fiction movie, the weed grew to deadly proportions. The Sepik River people of Papua New Guinea call it "garas nogut" — grass no good. In parts of the vast plains in the northern region, the plant is called the "priest's flower," after the man who accidentally introduced it to the area. Whatever its name, no one could have predicted the devastation it would bring.

As the story goes, a missionary used the plant in his fish tank in the early 1970s. After the weed grew too big, he

A Highlands village prepares to feast on an eel.

A Huli hunter cannot make up for lack of fish in the local diet.

emptied the tank, weeds and all, into the Sepik, the world's sixth largest river. In so doing, he unwittingly unleashed a scourge of biblical proportions.

The fast-growing weed soon choked off fishing. Once-navigable waters became so dense with the new growth that canoes were stalled. The plant even became an offensive weapon when some villagers planted it in the lagoons of neighbours with whom they were feuding. With its rapid growth and ability to quickly cover an open water surface, the weed — known as *Salvinia molesta* — afflicted the lives of over 80,000 people living along the banks of the Sepik River. Many believed the plant attacked their waterways in retaliation for past sins.

In 1980, the Government of Papua New Guinea turned to the Food and Agriculture Organization of the United Nations (FAO) for help. An aquatic weed expert was dispatched to plan an eradication campaign. Booms were constructed to halt further spread of *Salvinia molesta*. Aerial spraying was attempted, but did not offer a long-term solution. Most of the weeds on the surface died. But they were soon replaced by submerged plants that were not reached by the spray.

By 1981, it was obvious that a new approach was called for. The United Nations Development Programme (UNDP) joined FAO in launching a long-range project aimed at biological control of the fernlike plant. The venture soon drew additional support from the Australian-based Commonwealth Scientific and Industrial Research Organization.

A small beetle, known as the *Cyrtobagous salviniae*, was identified by Donald Sands, an Australian entomologist, as a devourer of numerous water plants. Mr. Sands believed that a weed like *Salvinia molesta* could be controlled more efficiently and safely by biological agents rather than chemical ones.

He proved his point. Less than two years after the beetles were introduced, more than two million tonnes of *Salvinia molesta* were destroyed. By the end of 1985, the weed had been brought fully under control. As the beetles in each lagoon ate their own food supply, they eventually became extinct.

The project's success sparked the beginning of an even greater United Nations involvement in improving the Sepik's fish yields. The Fisheries Division of the Papua New Guinea Government had long been studying the river's fish species. David Coates, a fisheries scientist from the United Kingdom, who was involved in this early work in 1981, found that the yield of fish from the floodplain of the Sepik was only about ten per cent of that in similar rivers on other continents.

"When we realized the Sepik's yield

Protein deficiency is a common malaise in villages along the Sepik's tributaries.

A researcher sorting fish for future study in the lab.

was only about 5,000 tonnes a year, compared to similar African rivers with 45,000 tonnes a year, we figured something strange was going on here," recalls Mr. Coates. "In some of the streams in the Highlands, there were no fish at all. Geologically speaking, the Sepik is a young river. Large numbers of freshwater fish have not had time to evolve."

To hasten that evolution, the government turned to UNDP for technical assistance in launching a fish stock enhancement project. Mr. Coates became the project's Chief Technical Adviser.

The Sepik, with its basin population of 350,000 people, was a prime area for stocking. But the scientific team added a new twist to the globally accepted technique of introducing freshwater fish into the Sepik. "This became the first river in the world to be methodically researched in advance to determine which species would be most appropriate for it," says Jan Wahlberg, the UNDP Resident Representative in Papua New Guinea. "This unprecedented project could well become a case study for stocking waterways all over the globe."

UNDP has earmarked US$984,200 for the four-year project, which is being carried out by FAO. The effort, which began in 1986, aims to avoid past mistakes made in other parts of the world, such as in East Africa's Lake Victoria, which was stocked in the late 1970s with Nile perch. The perch then devoured many smaller fish which local villagers had relied on for centuries for food. By extensively researching the types of fish already present in the Sepik River, biologists hope to reduce the risk of introducing predators which threaten native species. Says Mr. Coates: "While it's obvious that new fish should be put into the river network, we have to ensure that we keep ecological disturbances to a minimum."

A fisherman is lucky to catch enough for a family-sized meal.

UNDP photos by Cherie Hart

Although it is the world's sixth largest waterway, the Sepik yields fewer fish than most major rivers.

No one doubts that there is an urgent need for boosting fish yields. Severe protein deficiency is a problem among villages along the Sepik, with malnutrition affecting as much as 75 per cent of the population. The main diet is based on carbohydrates from the sweet potato and taro. Local residents eat every bit of protein they can find, including grasshoppers and birds, but still suffer from protein deficiency. Ironically, empty tin cans of mackerel imported from Japan litter many villages along the river. "If they had more fish, they'd eat them," says Paul Van Zweiten, a Dutch fisheries scientist working on the project.

Exploring the mountainous interior of Papua New Guinea is no easy task for fisheries scientists. The country is one of the world's least-known regions. David Dudgeon, a project-supported ecologist who is studying the available fish-food sources in the Sepik, recounts a close call he had one night when he was in a boat in one of the river's tributaries. "We were getting ready to batten down for sleep," recalls Mr. Dudgeon. "Suddenly, the boat began to take water. I lit a lantern and noticed several pairs of eyes staring back at us from the water. We were surrounded by crocodiles. We pumped water from the boat and escaped, just barely, to a safer anchorage."

To catch fish samples, biologists set up a net spanning the width of the river. Several hundred metres upstream, they pour a milky solution into the water, composed of rotonome, a plant extract. When the fish swim through the mixture, their gills close up and they die. Carried downstream and caught in the net, these fish are then collected for analysis. Patience is an asset. Three hours of this painstaking process can result in a catch of only a dozen fish.

More than sixty such field trips up and down the Sepik have been undertaken in the past half year. After another year of collecting samples, scientists will have a complete picture of the numbers, type and location of the local fish and the food they eat. From that data, researchers will be able to determine the most appropriate species with which to stock the river.

"We travel with buckets and shovels and collect what we can with bare hands. It's basic, but it works," says Mr. Dudgeon. "We are doing work never before undertaken anywhere in the world. I feel I'm part of a team that is making scientific history." ■

Can the Black Sea Be Saved?

Scientists are seeking ways to head off an environmental catastrophe.

By Mary Lynn Hanley

Sofia, Bulgaria — The Black Sea, whose waters lap the coastlines of Bulgaria, Romania, Turkey and the USSR, got its name from the fierce squalls and somber clouds which darken its shores each autumn. Beneath a surface tossed by these violent storms, this huge inland sea has sustained a thriving marine life for centuries. Now, however, the residues of modern agriculture and industry threaten to bury all living organisms inhabiting its waters under a cascade of poisonous chemicals.

"The Black Sea is on the verge of a catastrophe," says Professor Georgi D. Dechev, Head of Bulgaria's Institute of Ecology in Sofia, the Bulgarian capital. In fact, he warns, the situation is so bad that all life could disappear from the Black Sea and the chemicals poisoning it could begin polluting the atmosphere. "Whole towns would have to be evacuated," he says. "In small inlets one can already detect pollutants rising into the air."

There is still time, however, to head off such a disaster. With support from the United Nations Development Programme (UNDP) and other UN agencies, the coastal countries are now urgently exploring ways to halt the Black Sea's demise.

Prof. Dechev explains that the Black Sea is especially vulnerable to pollution because it collects ten times more water per square metre of surface area than any other sea or ocean. Much of that pollution gushes into the Sea from several major European rivers. The most important is the Danube, which flows through eight highly industrialized countries which also practice chemically intensive agriculture.

As it turns out, considerable pollution has been present in the Black Sea since the dawn of history. Beginning in ancient times, wind, rain and river waters annually deposited natural fertilizers in the form of leaves and other organic matter in the Sea. Over thousands of years, this biomass settled to the bottom and began to decompose and diminish the supply of oxygen.

Oxygen could not be replaced because of another peculiarity of the Sea: its two strata, consisting of a topmost layer of fresh water from the rivers that empty into it, and a lower layer of salt water, which pours through the Straits of the Bosporous from the Mediterranean to the south. As oxygen cannot penetrate below the layer of fresh water, the supply reaching the bottom has always been limited. Without it, decomposing matter produces hydrogen sulfide, which is toxic to living things.

"The Black Sea was in a steady state for thousands of years," says Prof. Dechev. "But large amounts of man-made fertilizers are disturbing the balance between the oxygenized and non-oxygenized layers." The problem has been made worse by the construction of dams for energy and irrigation on the rivers flowing into the sea. This has reduced the influx of fresh water by 50 cubic kilometres per year. For centuries, while nine tenths of the water in the Black Sea remained poisoned by the accumulation of hydrogen sulphide, a layer of water 200 metres deep just below the surface stayed fully oxygenized. Now, that layer has been reduced to a depth of only 80 to 100 metres.

Further deterioration of the Black Sea — and the air quality in the communities surrounding it — could spell economic as well as ecological calamity for the more than 150 million people living near the Sea and in the Danube River basin. For resource-poor Bulgaria, for example, Black Sea beaches are a flourishing tourist attraction which

Pollution threaters Black Sea resorts which generate vital revenues for Bulgaria.

Bulgarian Association for Tourism and Recreation

the country is hoping to further exploit. In fact, a 20-year plan prepared by the government for the development of 380 kilometres of Bulgarian coastline and adjacent districts to the north and south calls for bolstering tourism and the development of agriculture, transport and communications to support it.

The plan includes a total ban on any pollutants that might be discharged into the Black Sea. Another priority is to stop the concentrated industrialization in the centre of the Bulgarian coastal zone and to develop the less densely populated north and south. Twenty national institutions are investigating and monitoring environmental problems related to the plan — using equipment, consultants and training provided by UNDP and the UN Department of Technical Co-operation for Development.

Professor Dechev has a broad prescription for treating the Black Sea itself. Stopping the inflow of fertilizers and the building of dams, which diminish the amount of fresh water coming into the Sea, head his list. But perhaps most intriguing is his proposal for mussel culture. "Blue mussels act as a natural purifier at one-tenth the cost of a man-made plant," he says.

The mollusks thrive on plankton, which consume phosphates and nitrates and proliferate when there is an abundance of these nutrients. Raising mussels on a large scale would prevent plankton from multiplying and using up precious oxygen. Shellfish cultivation could also create profits. Blue mussels, which are a prized delicacy in many European countries, grow to four or five centimetres and are ready for the table in just a year.

"You cannot stop human development or industrial development," says Professor Dechev, "but we have to support the ecosystems so that they are able to reach a new stable level." He is hopeful that the region's decision makers will agree on a common anti-pollution strategy once sufficient research findings are in hand. With the support of UNDP, the World Health Organization and the UN Environment Programme, the coastal countries have been trying to agree on a convention to thoroughly assess the Sea's environmental problems and draw up a blueprint to attack them.

The latest round in these efforts was a workshop of international experts held late last year in Sofia to consider a joint Bulgarian-Soviet proposal to launch a research and monitoring programme, to be carried out by national scientific institutions and international organizations. A task force is now preparing a final draft of this proposal. It will be closely linked to a complementary international effort addressing the pollution problems of Europe's major rivers. Right now, it offers the best hope for keeping the Black Sea alive. ■

ENVIRONMENT

PHILIPPINES

Reviving Marine Resources

Philippine Fishermen and Scientists Join Forces

By David Kinley

Bolinao, Philippines — The sea has traditionally supplied the staples of life throughout much of the Philippines, a nation of over 7,100 islands. Nowhere is this more apparent than in the bustling beachside market here on the northwest coast of Luzon, where dozens of varieties of fresh and preserved seafood await sale beneath thatched canopies.

But such an abundance of seafood is increasingly rare now. Starting in the 1970s, fishermen across this far-flung archipelago began experiencing diminishing harvests. With incomes threatened, small children were hired by vessel operators to wade across the shoals and pound the reefs with metal rods, stampeding fish into waiting nets. In desperation, many small fishermen resorted to illegal blast fishing, using dynamite to stun their catch. Others dumped cyanide into the sea to capture colourful reef fish for living room aquariums overseas. The delicate coral reef was bleached and eventually died.

The cost of such marine ecological destruction has been steadily mounting across the Philippines. "Small-scale fishing is no longer viable on many stretches of this coastline because of overfishing, coastal pollution, sedimentation of the reefs and use of cyanide, illegal nets and dynamite," says Dr. Liana McManus, a marine biologist who directs the Marine Science Institute (MSI) in Bolinao. "One solution is for these small-scale fishermen to become seafarmers."

Fresh seafood is sold in the Bolinao market.

UNDP photos by David Kinley

Giant clams grown by the Marine Sciences Institute have high export potential.

"Seafarming" — the ecologically sound cultivation of all ocean resources — is proving a viable option for Virgilio Carolino and his neighbours in Lucero, a small fishing settlement of some 200 people about 15 minutes by speedboat from Bolinao. Mr. Carolino's earnings from the sea urchins he gathers on the flats near the shore have gone up dramatically in the past three years. He has abandoned his fish traps and his meagre trade in coconuts for a fulltime career in urchins. Ironically, Mr. Carolino attributes much of his recent success to "the ban" — a two-month annual prohibition on urchin harvesting imposed two years ago by Bolinao's town fathers at the urging of Dr. McManus' Institute.

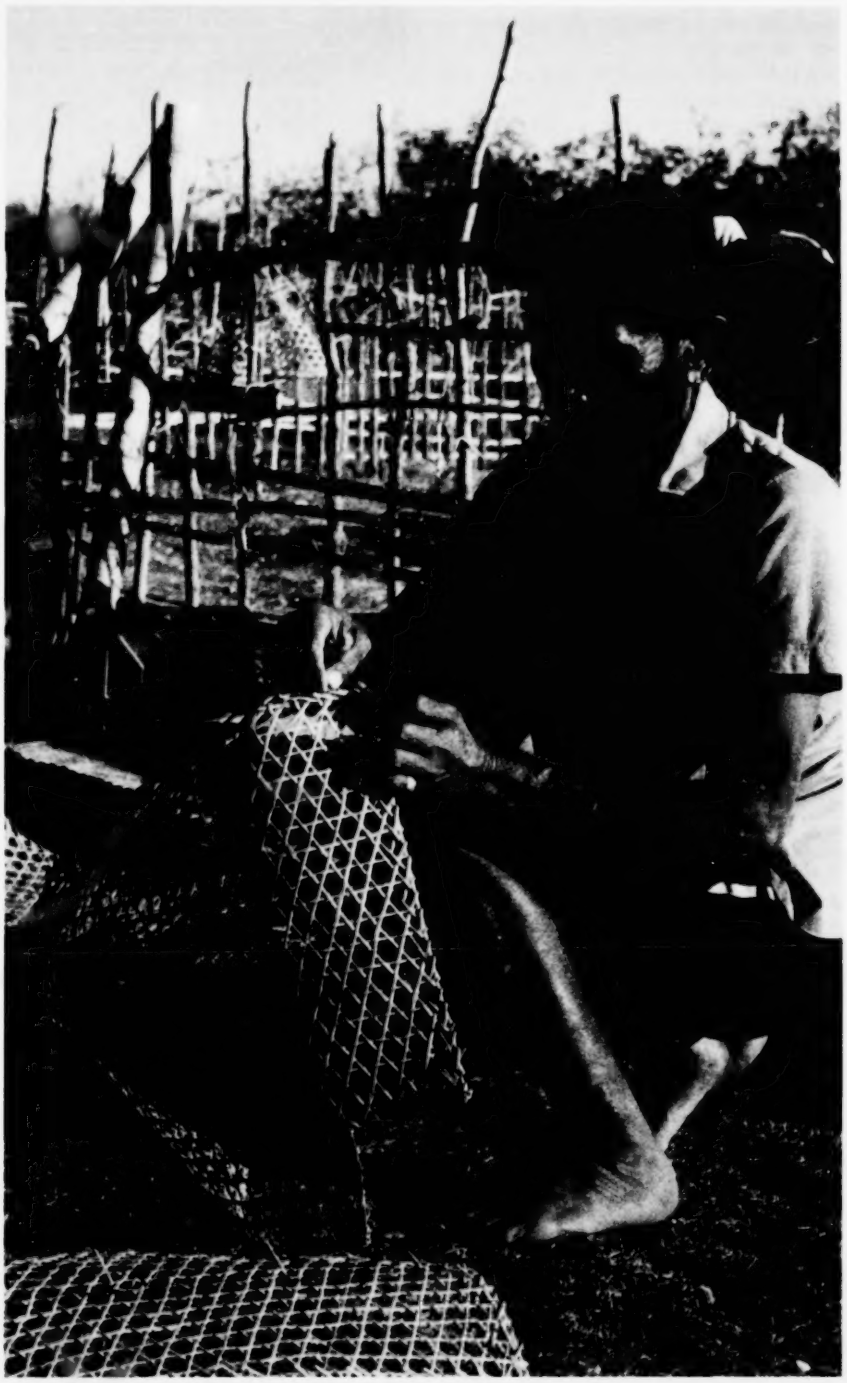
"When Japanese buyers from Manila began offering good prices for urchin roe in the mid-1980s, people all along the coast began harvesting them feverishly," says Mr. Carolino. "Soon, both the harvest and the size of the urchins began diminishing. Month after month, our incomes were falling."

Fortunately, the mayor of Bolinao took action, requesting help from Dr. McManus and her colleagues at the MSI, a collaborative venture of the University of the Philippines and the United Nations Development Programme (UNDP). A rapid analysis by scientists at MSI determined that many of the urchins being caught were immature, and that heavy harvesting was taking place during the spawning season in December and January. The MSI staff proposed that the town council institute a complete ban on harvesting during the spawning months and a prohibition on marketing of immature urchins.

Making such a ban effective, however, required the education and co-operation of the entire community around Bolinao. "Our first move was to get the Municipal Council behind the concept of a ban," says Merito Miguel, Bolinao's mayor. "Then we had to show the community that we were really serious. I put a couple of my own relatives in jail for violations."

UNDP photos by David Kinley

A fisherman builds a fish trap from local materials.



Bolinao mayor Merito Miguel and seafarmer Virgilio Carolino helped push through the urchin ban.

To gain support of the communities dependent on urchin gathering, scientists at MSI put together a brief slide presentation explaining the biology of sea urchin and why it is critical to protect them during spawning. Then they took the slideshow on the road to Lucero and other villages to win their backing. "At first, most of the urchin gatherers opposed the ban," says Mr. Carolino. "But once we understood the reasons for it, we were willing to give it a try."

The two-month halt in harvesting proved enormously successful. Before the ban started in 1988, the average earning of a gatherer was a mere US$2.50 to $5 a day. In the two seasons since the prohibition, the average earnings have leaped to $25 to $50 a day — almost tenfold. Surveys by MSI scientists reveal that the local urchin population is higher than ever before.

Meanwhile, the marine specialists at MSI have been busily applying their expertise in pursuit of a much broader objective: community-based management of renewable coastal resources in the Lingayen Gulf, a 2,000 square-kilometre section of the South China Sea to the east of Bolinao. With support from the United States Agency for International Development and the Association of Southeast Asian Nations, MSI is now launching an "Integrated Coastal Management Plan" for the entire gulf. Working with the Department of Trade and Industry, the pilot plan will engage coastal communities directly in marine conservation and economic development activities and promote alternative livelihoods for poor fishermen. They are being trained in the sea-farming of giant clams, oysters and seaweeds, production of peanuts and poultry, aquaculture and other small enterprises.

The lessons learned in working with the Municipal Council and urchin gatherers of Bolinao are being carefully applied elsewhere. "Coastal management has long been a top-down operation in the Philippines. Most often, it got stuck in the middle," explains Dr. McManus. "Now we are proving the value of working at the grass roots both in protecting the marine environment and benefitting the coastal people."

Almost a quarter million people live in the coastal areas of La Union and Pangasinan provinces bordering on the Lingayan Gulf. Tens of thousands of them still rely on uncontrolled fishing and gathering on the reefs. "The Lingayen Gulf represents a worst case scenario in coastal resource overuse," one recent analysis concluded. "The local population is both directly dependent on the area and responsible for its plight."

Armed with the country's first comprehensive plan for coastal resource management and the political support of local governments, MSI and its partners can begin to restore the ecological balance to this important section of Philippine coastline. If they do, indeed, succeed, they will be pioneering alternatives from which many other developing nations can benefit. ■

Dr. Liana McManus, Director of the MSI at Bolinao, holds a sea urchin.

UNDP photo by Emma Robson

This carp is expected to reach 20 kilogrammes, fattened exclusively on the polluting algae.

Chinese Carp Fight Reservoir Pollution in Morocco

Rabat, Morocco—To combat pollution and reduce treatment costs of its main drinking water reservoir, Morocco has been testing several techniques, including the successful use of Chinese silver carp to control algae.

Morocco's reservoirs suffer from eutrophication—the multiplication of microscopic surface algae, or phytoplankton, due to an over-abundance of nitrogen and phosphorus. When the algae die, they rob water of oxygen as they decompose and create nitrogen, ammonia and hydrogen sulphide—pollutants which add to treatment costs. Chinese silver carp feed almost exclusively on phytoplankton and thrive in warmer climates.

"Our reservoir was getting very polluted by algae," says Abderrahmane Bouloud, a biologist who manages the carp activities for Morocco's National Office of Drinking Water (ONEP). "These fish eat algae, and fisherman can eat the fish. It is an ideal arrangement."

In an experiment launched in 1987, 1.8 kilogrammes of silver carp fry were introduced into the Sidi Mohammed Ben Abdellah reservoir on the outskirts of Rabat, which supplies four million people along the Atlantic coast from Rabat to Casablanca.

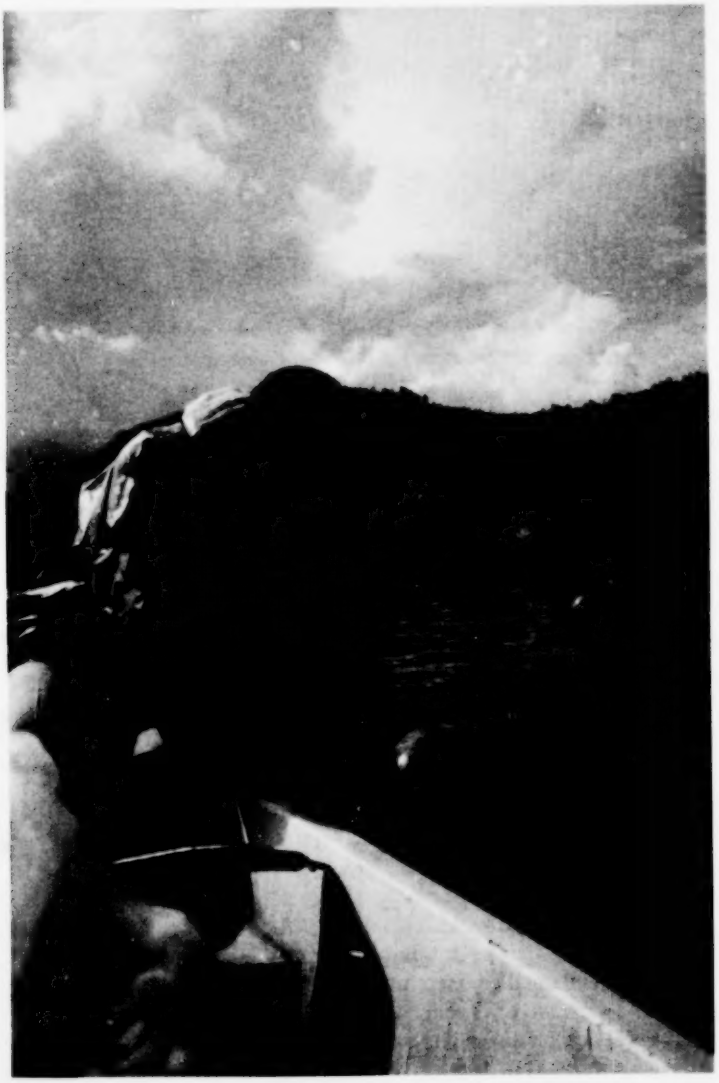
The experiment was part of a project supported by the United Nations Development Programme (UNDP) and World Health Organization (WHO). Its aim was to find low-cost solutions to Morocco's eutrophication problem. Eutrophication is a problem which has been closely analysed in temperate climates, particularly Scandinavia. But little research has been conducted in semi-arid and arid climates. The WHO-appointed experts from Sweden, Denmark and Canada were applying their northern knowledge to different and more complex conditions.

Dr. Richard Vollenweider, a Swiss expert who worked on the project on behalf of the Canadian National Water Research's Centre for Inland Water, says he believes Morocco's use of fish to purify a drinking water reservoir was a first for a warm country.

Eutrophication often stems from the discharge of domestic sewage or industrial effluents, as in the case of the algal bloom in the Adriatic Sea in summer 1989. In Morocco, it is caused by a surplus of chemical fertilizers which are swept off the treeless banks of the reservoirs by rainwater. While it is a problem which afflicts temperate climates usually only in summer, many artificial lakes in tropical, semi-arid and arid climates suffer from eutrophication all-year round.

The problem in the Rabat reservoir was most severe during the warmest months of the year, when treatment costs rose considerably. "Even with treatment, it was difficult to remove a nasty rotten egg taste," says Dr. Houssain Abouzaid, in charge of national water quality control at ONEP.

During the recent experiment, scientists conducted several water tests each week and studied the behaviour of the fish, which were suspended in cages in an arm of the reservoir which was cleared and partitioned for tests. Findings were compared with a similarly partitioned control area of the lake where there were no fish. In the arm containing the fish, levels of oxygen rose, par-



Biologist Abderrahmane Bouloud regularly monitors the water in the reservoir.

ticularly in the lower reaches, and light penetration increased as the algal mass diminished. "We also opened the fishes' stomachs periodically and found that, indeed, they were eating the algae," says Mr. Bouloud. Combined with another project recommendation—the selection of water from depths containing the least pollutants and most oxygen—the net result was dramatically lower water treatment costs.

Silver carp grow fast in warm waters and make a nutritious meal. Released into the reservoir in November 1987 when they weighed only 25 grammes, they weighed in at five kilogrammes after one year. In two years they weighed between eight and nine kilos. They are expected to finally tip the scales at 20 kilos apiece, fattened almost exclusively on the enemy algae.

Controlling the fish biomass in the reservoir is important to maintain a constant rate of purification. At a later stage, ONEP plans to restock the reservoir with more fry, but until now has relied on the growing food demands of the existing carp, which need running water to reproduce. Local fishermen overfished the reservoir in 1988, and the Ministry of Agriculture's Department of Waters, Forests and Soil Conservation banned fishing in the 1989 season at ONEP's request. "The fishermen were getting around US$6.50 a kilo and were very happy about it," says Mr. Bouloud.

"In countries with a continuous water supply, the diversion of polluted water is a valid option," says Dr. Vollenweider. In the 1960s, for example, Lake Washington in the United States was affected by serious eutrophication. Sewage treatment plants were constructed and the contaminated water was diverted by pipeline and purified. "This was impossible in the case of the Moroccan reservoir, which needs its six weeks a year of heavy rain to fill it." Artificial aeration of the reservoir water was also ruled out as being too expensive in Morocco's case. "The use of silver carp was the simplest and cheapest solution," says Dr. Vollenweider.

Due to the success of the experiment, ONEP plans to introduce carp in ten other reservoirs also suffering from eutrophication. The experiment could also serve as a model to other semi-arid and arid countries. Indeed, Mr. Bouloud has already visited Algeria and Tunisia to explain ONEP's experience.

—Emma Robson

A technician tests water for chemical substances.

UNDP photos by Emma Robson

EGYPT

Egypt's Hi-Tech, Low-Cost War on Pollution

By William N. Raiford

A visitor to Cairo doesn't have to be told he's in one of the world's most polluted cities. A constant stream of old cars and buses, many caught in traffic jams, spew out noxious gases. When mixed with smoke from the city's aging industries, the resulting smog can be both blinding and suffocating.

But change is in the air. Today a large BMW van packed with gas analyzers and other energy-measuring instruments is busy visiting factories all over Cairo and Alexandria. The van, a mobile diagnostic unit, measures energy efficiency. The data is then analyzed at the Tabbin Institute for Metallurgical Studies (TIMS) in Cairo to see how much energy the factories could save. Once energy efficiency is improved, an important spin-off is a reduction in pollution.

The diagnostic unit was purchased in 1985 with funds from a US$400,000 United Nations Development Programme (UNDP) grant to the Tabbin Institute to set up an Energy Conservation Centre. The Centre trains energy specialists and provides a link between TIMS and industry.

A government decree requires that all public companies appoint an energy officer and staff to monitor energy and promote conservation. But Egyptian factories have little incentive to conserve because they are also provided with huge energy subsidies. Moreover, factory owners have resisted spending money on costly measuring devices, all of which would have to be imported, using scarce foreign exchange.

Bernard Pierre Wolff Photo Researchers

In Cairo, emissions from traffic and industry often crowd out the sun.

UNDP photos by William N. Radford

TIMS aims to curb toxic discharges at plants such as this outside Cairo.

Egyptian Industries get door-to-door testing.

To overcome this reluctance, the Conservation Centre made the diagnostic unit available to any public sector company for the asking, thus sharply reducing the cost of testing. "The best thing UNDP did for us," says Dr. Mahmoud H. Selim, Director of TIMS, "was to provide a set of tools that gives us the technical basis to make energy conservation recommendations."

The El-Nasr Glass Company and the Alexandria Copper Works were the first two companies to be tested. Although computer calculations showed that both companies could recover the costs of installing energy conservation devices in two years, they balked at the more than $400,000 price tag.

At that point Luciano Cappelletti, UNDP Resident Representative in Egypt, offered to place $150,000 of UNDP's contribution to the Tabbin Institute in a special fund for buying energy conservation devices. A company could draw on the fund for up to 50 per cent of the cost of new equipment — with one condition, that as soon as these costs were recovered, the company would reimburse the fund.

El-Nasr Glass borrowed from the fund to invest in insulation materials and new burners for its oil furnace. It also bought a chimney recuperator to recover waste heat. It is now saving $200,000 per year. The Alexandria Copper Works purchased new equipment and an energy measurement control system for an annual saving of $260,000.

UNDP's total investment of less than $1 million has now attracted a 50-fold increase in funding from another donor. Last fall, the United States Agency for International Development signed a $49.5 million contract with the government to promote energy conservation. Both Sweden and Italy are also considering a contribution to the project.

As more factories adopt energy saving methods, the amount of toxic chemicals in the air will be further reduced, a move especially welcome to Egyptians in pollution-ridden Cairo. With an increasing number of less developed countries seeking economical ways of curbing pollution and cutting energy costs, Egypt's Energy Conservation Centre could well serve as a model to emulate. ■

Power to the people

By Cherie Hart

New Delhi, India—When solar power came to the Achada village of west India, electricity illuminated the streets, but it also sparked local feuds. One man became so indignant when his front yard was not chosen as a location for a light pole, he tied his buffalo to his neighbour's street light and yanked it down.

In another village, Brahmin traditions were put to the test with the introduction of solar cookers—insulated boxes fitted with mirrors to concentrate the sun's rays. Women in the area refused to prepare food outdoors. When they tried to use the cookers inside their homes, they became disgruntled when their meals remained cold.

New technologies bring light to remote villages of India

Developing cheap, clean energy is only half the task of the Department of Non-conventional Energy Sources (DNES), a part of the Indian Ministry of Energy. The department has its own social research unit to assess the impact of its projects on the behaviour and quality of life of the Indian people.

"If technology is being used incorrectly," says Dr. G.D. Sootha, Director of DNES, "our team explains to people why and how a particular device works. We now find Brahmins cooking outdoors. Even older villagers, quite set in their ways, have told us their eyesight and health have improved with solar cookers which preserve nutrition."

While traditions in India die hard, such education programmes are making way for new technology. When it comes to energy conservation, necessity warrants a major shift in thinking. "With an expected population of a billion people by the turn of the century, this country has to find ingenious ways of using scarce resources," says Dr. J. Gururaja, Adviser to India's Ministry of Energy. "Renewable energy has such substantial potential that we budget US$100 million a year for its development."

DNES sponsors research and development in a wide range of alternative energy technologies, including solar thermal energy, solar voltaics, biogas and wind energy. The United Nations Development Programme (UNDP) is contributing $1.5 million for testing, training and developing technology at the DNES Solar Energy Centre in Gurgaon, 35 kilometres south of Delhi.

With an average of 290 sunny days a year, India has targeted solar power as a vital energy resource for the future. Compared to the use of coal, oil and firewood, solar power is cheaper, cleaner and more abundant.

UNDP photo by Cherie Hart

Solar powered street lights in Delhi.

The country also has strong reserves of coal, but coal-based power plants pollute the air. Gas production is limited by a shortage of pipelines. Wood is the most commonly used non-commercial fuel and is in increasing demand in the rural areas. But with 15,000 hectares of land cleared every year for firewood in India, deforestation is leading to flooding, soil erosion and drought.

The Solar Energy Centre is India's lead institution for testing and stand-

ardizing solar devices and components. The nation has 150 manufacturers of solar systems whose products must be certified before they can be sold.

"In the short-term, we want to both save and provide energy for India," says H.R. Khan, Senior Scientific Officer at DNES. "In the long-term, we want to sell our products abroad. But we must first establish national standards for new technologies."

Last year, UNDP provided equipment, a computer and a software package for analyzing design durability and performance of solar cookers, hot water systems, water distillation units and solar refrigerators.

Besides test laboratories, more than 115 integrated village energy projects have been set-up through DNES. These pilot villages use a mix of technologies that harness locally available energy resources such as biogas, wind and solar power.

In Masoodpur, a test village five kilometres south of the Solar Energy Centre, all energy requirements are met through alternative sources. Women prepare food with biogas and solar cookers. A windmill is used to pump water for the town biogas plant, which is fueled by cow dung purchased from a local dairy farm. When mixed and processed with water, the dung provides enough gas for the villagers to cook five hours each day.

Saroj Bala, a resident of Masoodpur, says the biogas plant has changed her life. "At first we were afraid the gas would give off a foul smell," she says. "After we saw how it could help us, we were very happy. I no longer have to walk ten kilometres four times a week, just to gather firewood."

Pilot villages throughout India use alternative energy sources.

More than 3,000 Indian villages use photovoltaic electricity to power their street lights, water pumps and telephones. On exposure to sunlight, solar photovoltaic cells convert solar energy directly into electricity. While India produces 50,000 monocrystalline solar cell panels a year, the government has given priority to the development of amorphous silicon cells. Monocrystalline panels are made of carefully interconnected wafers of electronic grade silicon. Amorphous panels are simpler and less expensive to make because they require only a thin film of silicon deposited onto a panel.

"The current price of monocrystalline cells is about $4 per watt," says Dr. A.K. Batabyal, Project Director of the Indian Association for Cultivation of Science in Calcutta. "But amorphous cells are simpler to manufacture, and by 1995 may cost only 90 cents per watt. India must develop this new technology because importing it is very expensive."

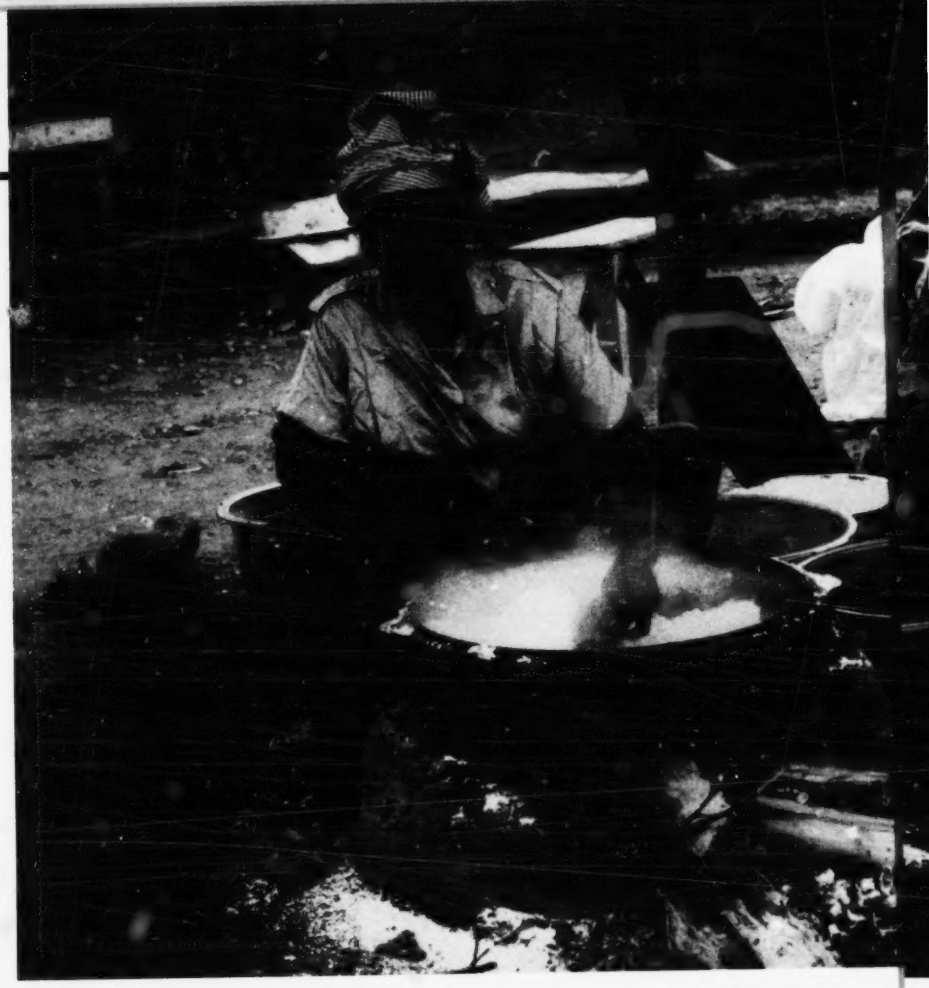
"Solar power is not yet economically competitive on a mass scale," says Ram Ragde, Senior Technical Advisor on Energy for the United Nations Fund for Science and Technology. "The cost of production must be brought down. Only technology can do that."

UNDP has funded equipment and short-term consultants for developing amorphous cells at the Calcutta research centre. The aim is to channel technology developed there into a pilot plant at the Solar Energy Centre near Delhi. By early next year, the test plant will be producing 5,000 amorphous silicon panels annually.

While electrification initially caused local feuds and solar cookers were anathema to certain Brahmins, alternative energy research in India continues to grow at a rapid pace. With time, local traditions are bound to warm to the idea of energy from the sun. ■

Biological Control

Battling the Cassava Mealybug



Cotonou, Republic of Benin—"It's just not true that the only good bug is a dead bug," says Dr. Hans Herren, standing outside a new twelve-sided, adobe brick laboratory complex here in Cotonou. Dr. Herren, the Swiss-born, US-trained head of the IITA's biocontrol programme, has spent the last ten years proving just the opposite—that predatory insects can be the most valuable weapons in the battle against African food crop pests. In fact, Dr. Herren's campaign to control cassava mealybugs is a classic story of how biological control can work on a continent-wide scale.

Brought to Africa from the Americas by Portuguese traders some 400 years ago, cassava has become one of the principal sources of calories and protein for millions of rural Africans. Cassava is propagated by taking a cutting from the stem and replanting it. Unfortunately, sometime in the early 970s, someone brought a cassava cutting from South America to the Congo and with it came the cassava mealybug and another pest, the green spider mite. The mealybug is the more dangerous, destroying the upper parts of the cassava plant and halting the growth of the tubers. It began to spread rapidly in the late 1970s, taking a heavy toll from Ghana to Zambia with losses mounting to US$2 billion a year.

A waxy covering on the mealybug enables it to repel pesticides. Wide-scale insecticide spraying was impossible anyway, given the tremendous area affected, the dispersed pattern of cassava cultivation in Africa and the high costs of dispensing chemical agents. So Dr. Herren and his col-

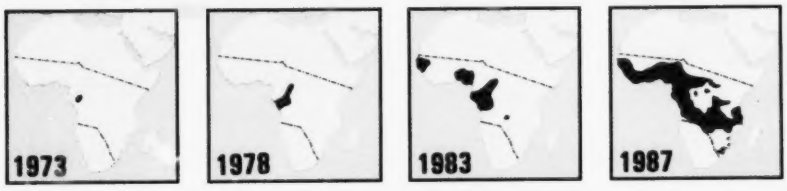
Dr. Hans Herren, director of IITA's biological control programme, inspects cassava damaged by mealybugs.

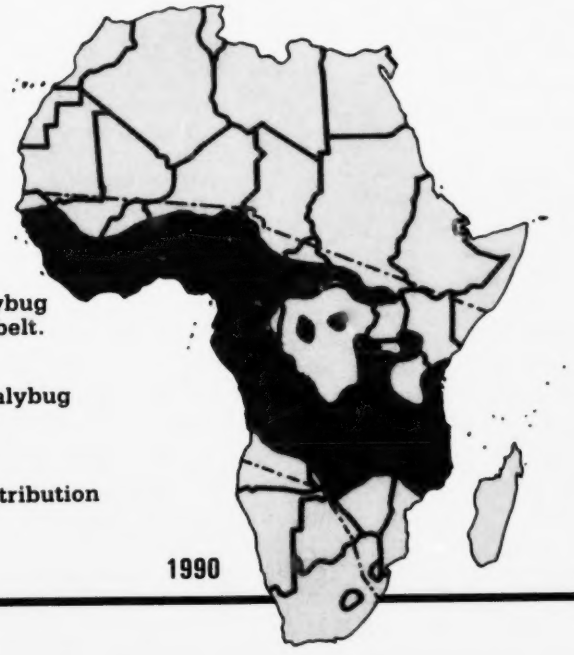
Dr. Alemayehu Wodageneh heads up a UNDP-funded training programme bringing biocontrol techniques to dozens of African countries

Photos by David Kinley / UNDP

Cuttings of IITA-improved cassava are sold for replanting.

Processing of cassava is time consuming, requiring fermentation, drying and cooking.





Spread of the mealybug across the cassava belt.

Cassava mealybug distribution

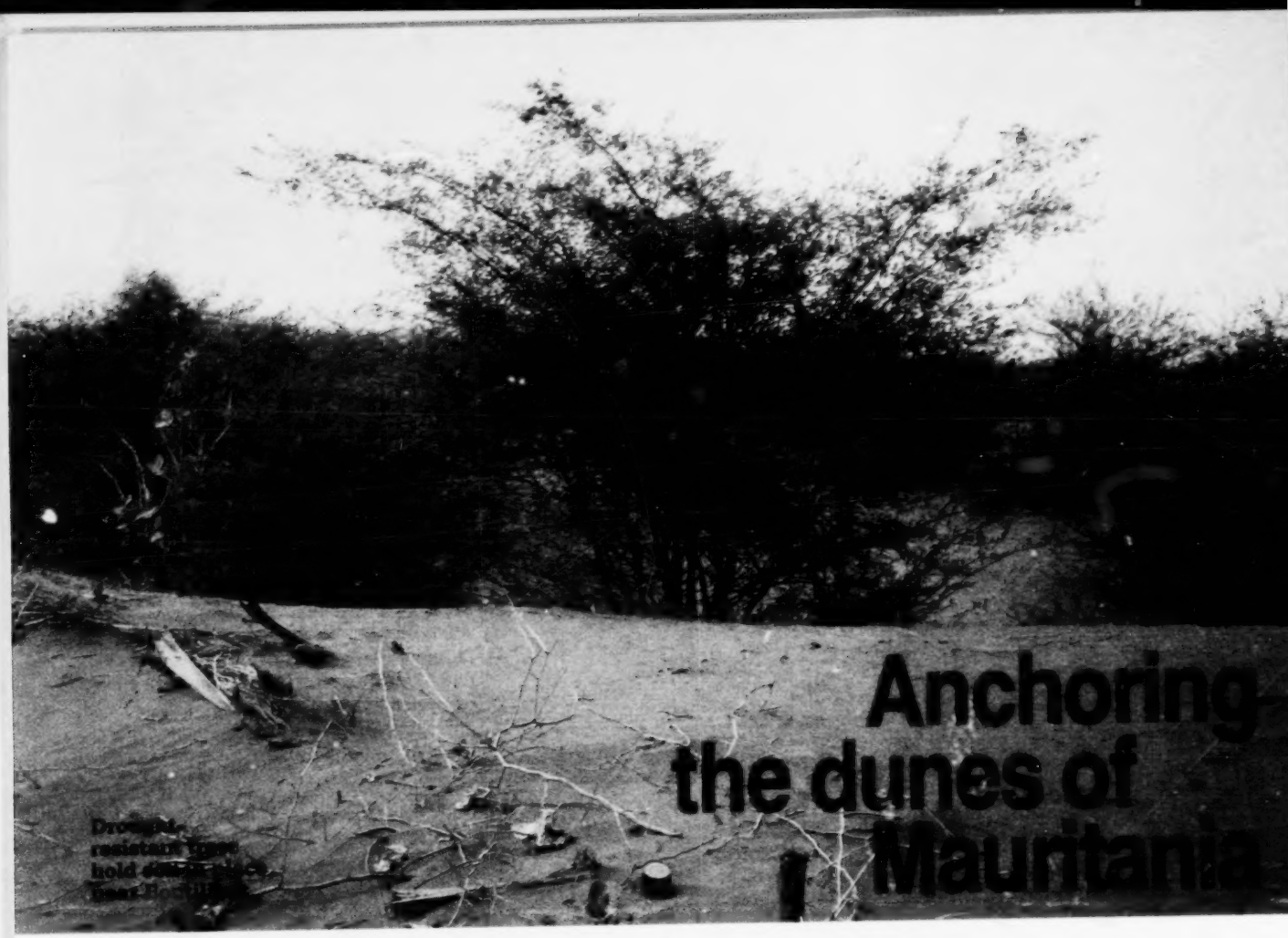
***E. Lopezi* distribution**

leagues began a long search for a biological solution.

Four years of intensive investigation in Central and South America led to the discovery of a predator wasp, *Epidinocarsis lopezi*, in Paraguay. The wasp preys on the mealybug by injecting an egg into the host which thrives by eating it from the inside out over the course of two weeks. A new wasp emerges from the mummified shell. The wasp preys only on the mealybug.

In early 1987, mass breeding of the tiny wasps began at IITA headquarters in Ibadan, Nigeria with a special grant from the International Fund for Agricultural Development. By the late 1980s, Dr. Herren and his partners were breeding 10,000 wasps a week at specially designed insectaries, and dispersing the bugs from a twin engine Beechcraft throughout mealybug-infested areas of West Africa. In 1987, the United Nations Development Programme (UNDP) also stepped in to help set up a biocontrol training programme for agricultural personnel from 38 African countries affected by the pest. And in 1988, Africa's first biocontrol centre—specially equipped to mass produce predatory insects—was dedicated here in Cotonou, with additional support from the Swiss, German, Austrian, Dutch, Danish, Norwegian, Swedish and Canadian governments.

Airborne and ground releases of the wasps have been undertaken in 19 African countries with impressive results stretching from Côte d'Ivoire to Malawi (see map). The biocontrol campaign is now being extended into newly affected areas of Eastern and Southern Africa. One evaluation study of the programme reveals that for every $1 spent on biocontrol, $140 is being returned in cassava harvests saved from the mealybug.—**DK**



Anchoring the dunes of Mauritania

Drought-resistant trees hold dunes in place near Boutilimit

By Mary Lynn Hanley

The Highway of Hope cuts through the heart of the West African nation of Mauritania, linking the capital of Nouakchott on the Atlantic with the town of Néma near the eastern border with Mali.

Despite its name, the road leads through a region which offers few signs of optimism. On the outskirts of Nouakchott a sprawling settlement of squatters is filled with persons displaced by the drought the country has endured almost unremittingly for the past 20 years.

Beyond the tents and makeshift wooden and tin shacks, great waves of sand extend as far as the eye can see, broken only by a few hardy desert shrubs or a lone acacia tree, its spindly roots laid bare by the wind.

Then there are the dunes. Massive and imposing, they threaten to engulf the road, overrun the meager pastures for goats and camels, and inundate the few settlements which have managed to hold out against the sands' unrelenting advance.

Until a few years ago, little attempt had been made to fight back. Now, with support from the United Nations Development Programme (UNDP) and other donors, two strategies have been devised to keep the sand from advancing any further.

Near the town of Boutilimit, 200 kilometres east of Nouakchott, a grove of young trees — mainly *Leptadania pyrotechnica* and *Balanites aegyptiaca* — suddenly springs from the earth. They are drought-resistent varieties, used to stabilize the dunes naturally rather than mechanically.

According to Houcine Khatteli, a Tunisian planning expert from the Food and Agriculture Organization of the UN (FAO), the secret behind this flourishing patch of green is a method of afforestation called "deep planting." It minimizes a tree's need for water by taking advantage of the moisture hidden well below the sand. "That moisture has been stocked for several years," says Mr. Khatteli. "It is buried beneath a dry zone of 30 centimetres."

A newly introduced sapling need be watered only once — when it is planted. That single dousing maintains the plant until its roots grow down to tap the moisture buried in the soil. Using this technique, over 700 hectares of dunes have been planted with 15 different drought-resistant tree species, of which nine are native to Mauritania. The results have been heartening.

A short distance from the grove are several mounds of sand which have been "fixed" by a second technique. Workers have laced the tops of dunes

UNDP's Demba Diop stands beside a desert tree with roots laid bare from erosion.

MAURITANIA

Sand dunes anchored with branches and leaves.

UNDP photos by Mary Lynn Hanley

with windbreaks made of dead branches, palm leaves and panels woven of twigs and leaves. These anchor the sand firmly in place. The technique is especially useful in areas where moisture lies buried too deep to make tree planting viable. It has been applied to 535 hectares.

The tree planting and windbreak strategies have been used singly or in combination to fix dunes on 15 different sites. UNDP has provided US$819,332 for the effort, which is executed by FAO. The Government of Denmark contributed US$2.6 million through the United Nations Sudano-Sahelian Office (UNSO). Support from the United Nations Capital Development Fund (UNCDF) totalled US$1.4 million. Other funding has come from the World Food Programme and the Mauritanian government.

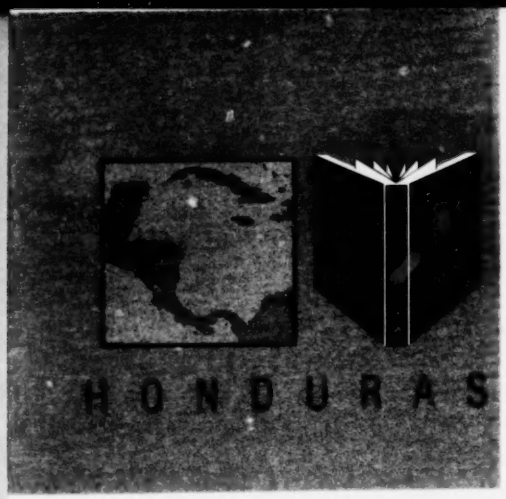
Mauritania, which is the size of France and Spain combined, has been the most affected by desertification of all the drought-prone countries of the Sahel, a group of African nations just below the Sahara desert extending as far east as Sudan.

Although the seasonal rains have come on schedule for the last two years, 15 years of drought since 1967 have taken a heavy ecological and social toll. As plant life was destroyed, the soil was exposed to erosion and the desert advanced inexorably. More than one-third of the country's estimated one million cattle died, as did 20 per cent of the 6 million sheep and goats. Deprived of their animals, Mauritania's traditionally nomadic population was forced to flock to the cities. Nouakchott, built for 30,000 inhabitants, has a population of more than 500,000.

But now the odds are shifting in favour of those mobilizing to halt the dunes. Fixation techniques have saved more than 10 kilometres of the Highway of Hope which were in danger of being swallowed up. The threat of being engulfed has also been removed from small communities totalling over 13,000 people. Blocking efforts prevented sand from inundating 715 hectares of arable land, as well as 65 hectares of palm groves containing 114 wells and 7,800 date palms. People in four villages were able to reoccupy homes they had abandoned due to sand encroachment, and in Boutilimit, an anti-desertification research centre was dug out and rehabilitated.

The drive to grow more trees has also made rapid progress. Seventeen new nurseries have produced over 534,350 saplings, and a forestry research centre was created that has already trained 286 technicians. "We put a great deal of importance on the training of villagers so that they will be able to carry on afforestation without any foreign assistance," says Mr. Khatteli.

The fight is hardly over. Mauritania has now prepared a US$23.5 million proposal for further sand dune fixation. UNDP will contribute US$1.5 million toward this next phase, while UNCDF is providing US$369,000. UNSO is continuing its support with US$5 million in additional assistance from Denmark. A donor conference will be held later this year to raise the rest. As the programme moves forward, the Highway of Hope may yet live up to its name. ■



Where Even the Children Know the Meaning of Ecology

By Peter Gall

Chagüite Grande, Honduras — It is late afternoon in this remote mountaintop village, and school is out for Norberto Coronado Andino, a fifth grader. But he remembers his environmental ABCs. "You don't cut trees, you save them," he tells a visitor. "We need them to earn money, for the fresh air and because there would be no water without them."

Forty kilometres away, in El Achiote, Andrés Mesa has continued farming and building a community three years after trees were cleared by the traditional slash and burn method. He used to seek out new forest land every few years. Encouraged by new farming techniques and seed varieties that he has been shown by extension agents, he has terraced the side of hills, sown corn, planted fruit trees and begun agitating for a better road into the village. "We get ideas from elsewhere, but it is self-development," he boasts.

Both Norberto and Mr. Mesa are among thousands of children and adults who have fallen under the influence of ESNACIFOR, Honduras' National School of Forestry Science. The school was founded in 1969 with a grant from the United Nations Development Programme (UNDP), and technical assistance from the Food and Agriculture Organization of the UN (FAO). The college, in Siguatepeque, 130 kilometres northwest of Tegucigalpa, is really a combination of forestry institute, research centre and purveyor of both social and environmental values. It has become such a national institution that it is portrayed on a Honduran 100-Lempira bill.

Its unique value lies in its impact on villages like Chagüite Grande and El Achiote and people like Norberto and Mr. Mesa. In Chagüite Grande, in fact, trees are now felled under a careful management plan after their resin has been collected for shellac and other paint products. The plan also includes an aggressive reforestation programme.

In Chagüite Grande, good conservation and sound agricultural and nutrition values are stressed from an early age. Two years ago, an ESNACIFOR student intern taught the children and their teacher to sow carrots, lettuce, onions and radishes on the slope below the school. The next step was to plant 5,000 pine seedlings in the surrounding woods and teach the children to care for them. The current village teacher continues the practice today.

UNDP photos by Ettiki Surila

Children in Chaguite Grande follow ABC's of planting and conserving pine trees.

With ESNACIFOR help, trees become a managed, renewable source of income.

It is crucial that Honduras both conserve and exploit its timber industry, since 45 per cent of the land is covered by forest. More than 30 per cent of the Honduran population, or one million people, live in the forest region. They are among the poorest in the country, with an average family income of US$216 a year. Yet only a tiny minority actually make their living from forestry. Most raise livestock, and often cut and burn the forest to provide grazing ground and wood for cooking and heat. The resulting loss of ground cover and increased erosion only makes the livelihood of forest dwellers more precarious. But since their needs are so immediate, long-term forestry projects held little interest for them. This is a prime educational challenge for Honduras, and for ESNACIFOR in particular.

According to Rubén Guevara, director of ESNACIFOR, the government originally established the institute with the aim of graduating forest rangers. In 1974 it was turned over to the newly formed, semi-autonomous Honduran Corporation of Forestry Development known as COHDEFOR. Its forestry graduates spend three years learning both the practical lessons of a forest ranger and the training needed to help people farm, build a sawmill or grade and sell timber.

Eventually, the school's focus on trees broadened to take in the people who live and work in and near the forests. In 1984, ESNACIFOR began to teach students to be rural teachers imparting environmental education. Today, extension agents trained at the school are targeting some 80,000 farmers around the country for help in tying their agriculture in with forestry. They are also receiving training in fighting forest fires, in organizing themselves to obtain clinics, clean water and schools from state bureaucracies, and in getting women more involved in the development process.

ESNACIFOR's success as a school bridging the nation's natural and human resources makes it a key player in a new COHDEFOR programme begun in early 1989 with the support of UNDP and the Dutch government. The initiative — to strengthen Honduras' "Social Forestry System" — will concentrate on 38 poor communities that are drawing their living from the forest.

The new initiative will try to build on the experience gained in Chaguite Grande and in El Achiote. The aim is not only to assist forest dwellers to boost their incomes from timber, but to help them see the reasons to conserve and manage the forest so it will serve them for years to come. Revolving loan funds are a key element in trying to turn poor forest workers into owners or members of co-operatives managing small forest-based businesses, whether it be in timber or environmentally sound cattle raising.

ESNACIFOR's role is to prepare much of the audio-visual and other teaching materials necessary to communicate clearly to the target audience. The college will also train extension agents to combine traditional forestry management with the economic and social requirements of the 38 communities.

Now the National School of Forestry Sciences has 72 full-time students from Honduras and neighbouring countries and trains 1,500 other forest-related workers and experts. It has grown from what Rubén Guevara calls "an ugly little outfit" in the town of Siguatepeque in the early 1970s to a campus of 25 buildings on its own spacious, forested grounds. But its lasting value, says Mr. Guevara, will be measured by what it can do to strengthen the Social Forestry System and to act as an agent for long-lasting change among the people of the Honduran forest. ■

Sorting Out Solutions to Waste

By Lois Jensen

United Nations, NY—"Greenwich Village Recycles," says a black and white advertisement splashed across the side of a New York City bus. Even in the United States, landfills are running out of space. And pollution-conscious Europeans worry about the effects of incineration on their once pristine skies. Waste management in the industrialized world has come into vogue.

Yet people in the developing countries have been taking garbage seriously for years. In Mexico City, 10,000 scavengers make their living—barely—on the city's dump. In Bangkok, Thailand, municipal sanitation workers double their salaries by ferreting out and selling used paper, bottles, cans and plastics. As the following report from Cairo reveals, an elaborate, century-old system of handling household refuse provides an income for 16,000 *Zabbaleen*, or garbage collectors, who recycle nearly half of the 5,000 tonnes of trash produced by that city daily.

The sheer size of many Third World cities—and their runaway growth rates—makes the waste situation alarming. Collection and disposal of solid waste alone already consumes up to 50 per cent of some municipal operating budgets. And only 50 to 70 per cent of urban trash is usually collected. What remains mounts up in the poorest neighbourhoods, providing a breeding ground for rodents and disease. Or it is illegally dumped or burned, with little regard for environmental consequences.

New techniques for managing waste in the industrialized countries—from bombarding it with infrared beams to feeding it to genetically-engineered microbes—verge on science fiction. In contrast, solutions in the developing world are more a matter of experience and common sense, says Jack Fritz of the World Bank, who heads up a US$2 million global resource recovery project financed largely by the United Nations Development Programme (UNDP). Carl Bartone, another Bank official associated with the project, agrees. "Ninety-five per cent of the waste in developing countries could be handled by safe landfills, combined with the recycling that goes on anyway," he says. "The main stumbling blocks are not technical. They are organizational and institutional."

The resource recovery project, initiated in 1981 as part of the International Drinking Water Supply and Sanitation Decade, has documented a number of successful innovations in waste management and recycling around the world. Several Latin American cities are bringing private sector companies into garbage collection and disposal, creating competition and reducing inefficiency.

Community involvement is another key to extending service to low-income areas while also creating employment and keeping costs down. In Douala, Cameroon, garbage collection in certain low-income neighbourhoods is being successfully organized by communities themselves. In Medellín, Colombia, former landfill scavengers have formed co-operatives and have begun processing industrial and household wastes.

While integrating informal sector activities into the municipal system can be fraught with difficulties, it can also entail a radical shift in attitude on the part of both the municipal authorities and the lending institutions that assist them. "If you look at the loans the World Bank has made in the past in solid waste management, they have been mainly for equipment—for financing trucks and occasional composting plants—not for community-based approaches," says Roland Schertenleib, a Swiss engineer now on a year's sabbatical at the Bank. "But that is changing now. Urban administrations are simply overwhelmed. At some point, people have to begin taking charge themselves. But it will take a lot of institution building, a lot of community organizing and awareness." ■